which makes inappreciable any errors arising from change in the freezing point with the aging of the glass. This together with its low freezing point makes alcohol valuable for low-temperature thermometers, but great care must be exercised in their manufacture if they are to be at all accurate. Thus alcohol thermometers are liable to read too low because of age, especially if exposed to direct sunlight, which causes a change in the nature of the alcohol or the contained compounds.

The reason for the greater number of mercury thermometers reading too high is doubtless the contraction of the glass with age. While the scale is not marked on the glass in most cheap thermometers, the aging of the glass operates in the same manner in lifting the freezing mark, assuming that the thermometer is rigidly attached to the scale. If the scale slips, another irregular error will, of course, be introduced. It has been found that a thermometer graduated the day it is filled will read 1.5° higher a week later; if not graduated for one and a half years after filling, it will still read 0.5° too high in 6 years. Subjecting a thermometer to a low temperature, as −40° F., also appears slightly to raise the freezing point.

Other errors in thermometers result from faulty exposure and ventilation. A thermometer hung against the wall of a house, for instance, does not show the exact air temperature in cold weather, being influenced by conduction and radiation from the heated house. It is therefore better to hang a thermometer on a porch post, or support it at a distance from a window, than to fasten it directly to the wall.

During clear nights, especially during the winter in the middle and higher latitudes, it is observed that in calm weather the valleys are colder than the surrounding hills up to a certain altitude. The cause of this phenomenon is the nocturnal radiation from the surface of the earth into space. A deep snow cover intensifies the effect. The resulting cooling of the ground cools the adjacent layer of air, and since cold air is heavier than warm, the coldest layers lie nearest the ground in calm weather. Where the surface is not level, it follows that these cold layers of air flow down into the hollows, thus making them colder on still winter nights than the inclosing uplands.

### CONCLUSIONS.

(1) The average outdoor household thermometer is about 3° (F.) in error at low temperatures.

(2) Most thermometers read too high. Alcohol thermometers read too low.

(3) The amount of error increases with extremes of temperature.

(4) The variations in the reports of low temperatures in a mountain community are due to—

(*a*) Faulty construction, calibration, and exposure of the thermometer, and its age.

(*b*) Topographical factors affecting the location of the thermometer.

*Condensed table of mean deviations from the standard thermometer.*

| Number of observations. | Mean standard temperature. | Mean error. | Number of observations. | Mean standard temperature. | Mean error. |
|---|---|---|---|---|---|
| 23 | −1.2 | 2.2 | 19 | −22.5 | 3.7 |
| 44 | −10.1 | 2.9 | 23 | −27.0 | 3.8 |
| 64 | −15.9 | 3.1 | 24 | −28.1 | 4.2 |

## TEMPERATURE AND RELATIVE HUMIDITY IN COLD STORAGE PLANTS FOR EGGS AND CANDY.

By OWEN T. LAY, Observer.

[U. S. Weather Bureau, Chicago, Ill. Jan. 8, 1921.]

SYNOPSIS

An account of the writer's experience in an investigation of aqueous vapor in its relation to certain cold storage problems. Following are some of the points discussed:

1. The temperature should be kept low for eggs and moderate for most kinds of candy.
2. The relative humidity should be comparatively high for eggs and low for candy.
3. The sling psychrometer was found to be the most practicable method of finding the relative humidity in different parts of the storage rooms.
4. The demand for such work has steadily increased in Chicago.
5. The probability that there is a latent field for such specialized work in other commercial centers.

Early in 1918 the writer was requested by the manager of one of the largest and most modern cold storage plants in Chicago to assist in an investigation of aqueous vapor in its relation to certain cold storage problems, especially in the storage of eggs.

In order to preserve eggs fresh successfully it is of course necessary for them to be so handled that the life germ (in those that are fertile) is kept dormant, this generally being accomplished by providing a uniform temperature slightly above their freezing point, which is near 28° but varies somewhat with the time of year when laid; and at the same time, keeping the air in the storage room pure, with just the right amount of well diffused water vapor. If the relative humidity is too low the interior moisture of the egg will escape, resulting in a loss in weight and a product that must be placed on the market at a loss as "shrunken;" while, on the other hand, if a high relative humidity obtains for any considerable period mold will form on the cases, fillers, and eggs and affect the flavor seriously.

Throughout the first season, closing in January, 1919, humidity inspections were made biweekly in eight rooms, containing approximately 20,000 cases each, it being found that in these heavily insulated rooms which were kept sealed almost constantly, the temperature could be held within 0.5° of the desired degree and the relative humidity held quite constant, although tending to increase gradually as the season advanced. To combat this increase varying quantities of unslaked lime were introduced and at times calcium chloride boxes were used in conjunction with electric fans. However, it was learned that the arbitrary standard of about 88 per cent for the relative humidity was too high, this percentage having been thought about right by many experienced cold storage men; hence, readjustment to a lower percentage was found advisable for the second season, which extended from May, 1919, to January, 1920.

During the second season 14 rooms in the same plant, containing about 250,000 cases, were inspected weekly. Through study of the data gathered during the preceding season, much more desirable results were secured; while, during the third season, closing with January, 1921, the work was expanded to include four storage houses, with about 600,000 cases of eggs and 10,000,000 pounds of candy. The candy included chocolate creams, chocolate nut bars, caramels, hard candies, etc., two ozone machines being used occasionally in keeping the air clean. Most kinds of candy keep best in a dry room, with moderate temperature.

Thanks to the zealous care of those in charge of the mechanical side of the cold storage houses, the practical

experience of the superintendents and some of the temperature control men, who now have a basis of carefully compiled data for their own building, reports indicate that the season now closing has been remarkably successful, compliments from customers being general at the time of removal of goods, with no complaints yet made, although some of the eggs have been held eight or more months and some of the candy for about one year.

It has been found that sling psychrometer readings are the most practical method of finding the relative humidity in different portions of the rooms, a special cold storage instrument graduated to tenths of degrees being very convenient, as well as exact, if carefully used. However, this instrument is intended only for readings of 40° or lower and can not be used in some candy storage rooms. Graphs are prepared for each room to show the progressive trend of temperature and humidity, temperature readings being taken every four to six hours. At the time the product goes out of storage the factors influencing its condition are plotted for comparison with the ideal sought.

The investigation has included brick, concrete, and wooden buildings, with different methods of refrigeration and various kinds of insulation. As a result of the facts learned, the firm for which this line of work was first undertaken is now reconstructing a large warehouse so that the factors of temperature, humidity ,and air circulation may be absolutely controlled mechanically, thus enabling them to handle such products as eggs and candy under exactly the conditions desired at all times.

Some of the reasons which influence practical business men to demand such a special service from an outsider are: (1) That the man so employed may combine his training with an ever broadening experience with different firms and in various kinds of plants so as to act as an adviser in new problems which arise from time to time; (2) that he will be in a position to give warning of any departures from a standard margin of safety and suggest means for their immediate correction; (3) that he may serve as an unbiased check upon regular employees who might be inclined to relax vigilance at times; (4) the fact of their having an outsider on the alert for any possible improvements in handling goods has a real value in securing business in competition with other firms which may be drifting along by rule of thumb.

In view of the increasing local interest in temperature and humidity control in the storage of foods and in many problems of manufacture, it would seem that there is a latent field for specialized work in each of the large commercial centers of the country.

## THE DISTRIBUTION OF CLIMATOLOGICAL STATIONS.

By CLARENCE J. ROOT, Meteorologist.

[Weather Bureau, Springfield, Ill., 1920.]

In an article appearing in the February, 1920, number of the *"Bulletin of the American Meteorological Society,"* Prof. J. Warren Smith is quoted as saying:

> An expression of opinion should be obtained also in connection with temperature records. Do we have enough of these? Do we have too many at present, and should part of the money now expended in that connection be put into more rainfall records?

The statements that follow are written for the purpose of bringing out a discussion of the subject, and the opinions of men who have had experience in climatological work would be valuable and interesting.

In an area with varied topographical conditions, a large number of temperature and all-year precipitation stations are no doubt needed, but Illinois, with the exception of its two hilly areas, is an almost level prairie. The influence of Lake Michigan is felt in the extreme northeast portion of the State. Does Illinois need 64 full all-year weather stations, with 6 regular stations on its immediate borders but in other States?

Illinois is the second agricultural State in the Union, and the needs of agriculture should be given prime consideration. Except in the hill areas and near Lake Michigan, the temperature differences are principally those of latitude and the movements of cyclonic disturbances. The distribution of precipitation during the winter six months is quite uniform over rather large areas. During the summer months, and to a large extent in the spring and fall, the rainfall is of the local shower type. Great variations, both as to amount and time, occur over very limited areas, and here the question arises, Have we enough precipitation stations in Illinois during the crop-growing season?

There is another argument in favor of increasing the number of summer precipitation stations rather than to establish additional all-year stations. It requires considerable skill to properly handle the precipitation feature during the winter, and acceptable observers can not be found in every community. Then, too, the extra work of making snowfall measurements, and the inclement weather in which the duties must be performed, deter many from undertaking the obligation. On the other hand, almost any one would be glad to measure summer showers for the Government and the duties are so simple that any reliable person would be acceptable for this service. He would make entries only in column 7, Form 1009, Meteorological.

As an experiment, the writer prepared two maps of the State (Illinois), one showing the effect of enforcing the 25-mile limitation, and the other showing the effect of a 40-mile limitation for the all-year stations. A compass was set for a radius of 40 miles and circles were drawn about the regular station in and bordering on Illinois. Then places such as Rockford (an important city), and Urbana (the University of Illinois) were selected as permanent stations. Circles were then drawn about other stations in such manner as to give a good geographical distribution. The stations falling within the radii of these circles were considered unnecessary. An enforcement of the 25-mile limit would reduce the number of full stations (temperature and precipitation) from 64 to 41. The 40-mile limitation would reduce the number from 64 to 24.

It might be advisable to establish 175 crop-season rainfall stations in the State. With the 24 all-year stations, there would be about 200 summer precipitation stations, or about an average of two to a county. The money saved in thermometers, shelters, and supports should more than offset the expense of the additional rain gages.